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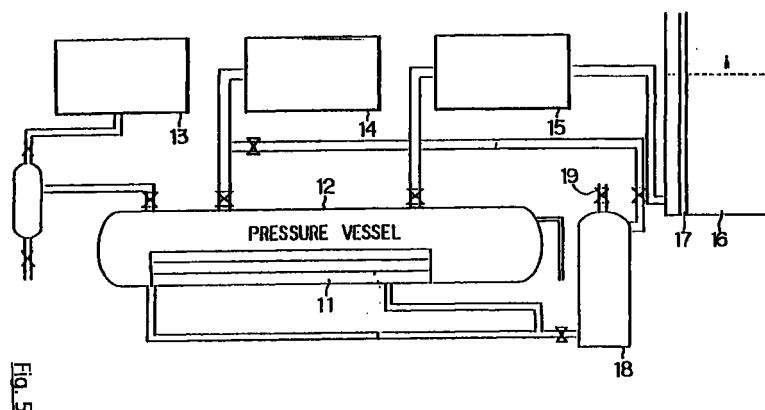
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This application was filed on 10 - 05 - 2000 as a  
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(54) **Apparatus for injecting a treating liquid into wood material**

(57) An apparatus for injecting a treating liquid into wood material comprises: a pressure vessel (12) for storing and sealing said material (11) to be treated therein; a pressure reducing pump (13) for reducing the pressure of said pressure vessel (12) after storing and sealing said material (11) in said pressure vessel (12); a liquid pressure applying device (15) for introducing the treating liquid from a tank (16) for said treating liquid into said pressure vessel (12) to fill up the vessel (12) with the liquid and apply pressure to inject the liquid into said material (11); a pressure removing tank (18) connected to said pressure vessel (12), whose pressure is previously equalized by gas from a gas pressure applying compressor (14) with the pressure of the pressure vessel (12); and a pressure removing valve (19) which opens to gradually reduce the pressure of said pressure

vessel (12) through said pressure removing tank (18); wherein the material (11) is stored and sealed in the pressure vessel (12); the pressure of the pressure vessel (12) is reduced by the pressure reducing pump (13), the treating liquid is introduced from the tank (16) to the pressure vessel (12) to fill up the vessel (12) with the liquid and apply pressure to inject the liquid into the material in the pressure vessel (12); the gas is applied from the gas applying compressor (14) to the pressure removing tank (18) to previously equalize the pressure of the tank (18) with that of the pressure vessel (12); and the pressure removing valve (19) is opened to gradually reduce the pressure of the pressure vessel (12) through the pressure removing tank (18) to obtain a liquid injected material product.



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## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

[0001] The present invention relates to an apparatus for injecting a treating liquid into wood material.

#### Description of the Related Arts

[0002] From the US-A-1 602 577 a process of preserving wood is known which comprises submitting the wood to a gaseous atmosphere at a pressure above atmospheric pressure, submitting the wood to the action of a liquid preservative at a pressure substantially above that of the gaseous atmosphere, thereby coating the walls of the interior cells of the wood with the preservative, removing the gaseous atmosphere and surplus preservative from the cells of the wood, and then submitting the wood to a liquid preservative at a pressure substantially above atmospheric pressure to seal the cells of the wood.

[0003] The WO 85/03474 describes a method for impregnating wood by means of an impregnating liquid, wherein the wood is placed in an airtight, pressure resistant impregnation tank from which the air is completely or almost completely evacuated, and the impregnating liquid, following its introduction into the tank, is subjected to pressure. The impregnating liquid is completely or almost completely de-aerated of its gas and/or air content before it is compressed in the impregnation tank. Impregnation occurs under completely airtight conditions, whereby the liquid is completely or almost completely devoid of gas and air during impregnation, i.e., when the liquid is penetrating into the wood, and gas and/or air have no opportunity to penetrate into the wood between the evacuation of the tank and impregnation of the wood.

[0004] In the GB-A-2 021 952 a method of treating timber is described, which comprises the steps of drawing an initial vacuum in the timber, contacting the timber with a liquid preservative composition comprising a solution of a preservative in an organic solvent, applying a positive pressure to the preservative composition in contact with the timber to urge the composition into the timber, removing the preservative composition from contact with the timber, optionally applying a second vacuum to the timber to withdraw excess preservative composition from the timber and contacting the timber with a gas at a positive pressure to cause the preservative composition within the timber to penetrate further into the timber.

[0005] Furthermore, various methods have been used for injecting treating liquids into the wood material for making it highly flame resistant, rot resistant and insect resistant, and for giving it high dimensional stability and increased strength.

[0006] The treating liquids have been injected into the wood material by applying thereupon pressure right up to a specified pressure in a short time while maintaining that pressure for a long period of time. In this case, though depending on the kind of wood material used, the injection of the treating liquid has been generally carried out at a pressure not more than 1471 kPa (15 kg/cm<sup>2</sup>) because injection carried out above this pressure causes the wood material to deform such as to warp, bend, or to become thinner.

[0007] The wood material generally has many groups of cells as shown in Fig. 7. Between each cell is a structure consisting of a wall pit-pair 1 scattered about forming wall pit 2 as shown in Fig. 7. At the centre of the wall hole 2 is a hyperplastic portion, called a torus 3. The torus 3 is surrounded by a thin mesh-like pattern (margo). In the wood material having this kind of structure, in the process of processing the wood material into heartwood and the like, the wall pit wall is drawn toward one of the pit openings, so that the torus 3 blocks the pit opening. The wood material in this condition is said to have an aspirated pit-pair. When the wood material has an aspirated pit-pair, the torus 3 blocks the pit 2. The wall pit 2 in the heartwood as well as those in the sap wood are also blocked by the torus 3. For this reason, in order to spread the treating liquid throughout the wood material, it is necessary to destroy the torus 3 which blocks the pit opening of an aspirated pit-pair, or to destroy the cell wall itself, so that the treating liquid can permeate into adjacent cells.

[0008] In order to destroy the torus 3 to those at the centre of the material, an applied pressure of 2942 kPa (30 kg/cm<sup>2</sup>) has been required using the conventional treating liquid injecting methods. However, as described above the material has been deformed at an applied pressure of 1471 kPa (15 kg/cm<sup>2</sup>) or more. As a result, it has been necessary to carry out the injection at a low pressure which does not cause deformation of the material. Consequently, there has not been enough pressure to destroy the torus 3 adequately and inject sufficient treating liquid into the interior of the wood material.

[0009] On the other hand, particularly for broadleaf trees, pressure is applied to the wood material to a pre-determined pressure. For this reason, impurities such as tylose get clogged in the vessels, making it extremely difficult to inject the treating liquid to the central portion of the material.

### SUMMARY OF THE INVENTION

[0010] The present invention is intended to overcome the above-described problems and has as its object the provision of an apparatus for injecting a treating liquid into wood material so that the treating liquid spreads throughout the interior thereof, without deforming the wood material.

[0011] The above objects are accomplished by the

apparatus according to claim 1.

**[0012]** The apparatus prevents air expansion from breaking the material while pressure is being removed, allowing the treating liquid to be injected into the central portion of the material.

**[0013]** The known art does not employ the concept of „pressure-removing tank“ for the following reasons:

- \* The treating liquid which permeates into a timber by static pressure does not reach the core part of the timber. It is therefore not necessary to taken into consideration destroying a treating wood by expansion of gas in the mixture of liquid and gas on account of rapid pressure down to atmospheric pressure after injecting.
- \* Pressurising to high pressure such as 2942 to 3923 kPa (30 to 40 kg/cm<sup>2</sup>) causes deformation of the timber or breakdown of the same at the time of decompression. Consequently, pressurising up to 1471 kPa (15 kg/cm<sup>2</sup>) or higher has not been considered and, therefore, it has been unnecessary to take any measure for avoiding undesirable effect which may be caused by a quick pressure-removing.

**[0014]** Thus, the conventional system has suffered from the following shortcomings or drawbacks:

(1) Due to the use of static pressure and applying pressure is low pressure below than 1471 kPa (15 kg/cm<sup>2</sup>), permeation or injection of the liquid is ceased when the externally applied injection or supply pressure is balanced by the pressure of the air compressed in the timber.

(2) When the atmospheric pressure is recovered after completion of the injection, the liquid is blown back by the internal air of the wood which expands rapidly since the pressure is reduced to the atmospheric pressure at once. (This is the reason why post-exhaust step is employed in known arts.)

(3) The pressurising is conducted in one step so that, when the pressure has been elevated, weak portion of the timber tends to be depressed or concave due to large pressure difference between the interior and the exterior of the timber. Hitherto, therefore, it has been impossible to elevate the pressure to a high level.

(4) Even when the high pressure has been achieved, the timber tends to be broken when the pressure is removed due to the fact that the pressure-removing is done in one step, since the internal compressed air tends to rush out of the timber.

**[0015]** For these reasons, it has been a common

understanding that the upper limit of the pressure is 1471 kPa (15 kg/cm<sup>2</sup>) in case of timbers, particularly conifers. Since conifers, in particular pine tree, requires sufficient injection, the above-mentioned upper limit of the pressure has posed a practical restriction on the injection technique.

**[0016]** The invention of this application eliminates the above-described problems by using a pressure-removing tank. In this pressure-removing tank, the liquid pressure inside a can is held at the same level as the pressure of the gas inside the pressure-removing tank. The gas which exhibits a large volumetric change is progressively discharged to the ambient air so that the pressure of the liquid inside the can is progressively and gradually lowered. It is therefore possible to prevent quick re-expansion of the air which has been compressed in the timber and a consequent breakdown of the timber.

**[0017]** According to the invention of this application, no substantial problem is caused even when the pressure is elevated to 3923 kPa (40 kg/cm<sup>2</sup>) or so, thanks to the progressive removing of the pressure performed by the pressure-removing tank.

**[0018]** Thus, the invention offers the following advantages:

(1) Air inside the timber is compressed to minimum volume due to the employment of the high pressure, so that the liquid can permeate sufficiently deep into the timber. At the same time, excessive air is dissolved into the liquid so that injection is never hampered.

(2) Since the pressure is relieved gently or gradually, the gases which have smaller molecular sizes come out the timber preferentially to the liquid, so that sufficiently large quantity of the gas remain inside the timber.

**[0019]** Injection of the liquid at such high pressure as 3923 kPa (40 kg/cm<sup>2</sup>) can never be conducted into conifers, in particular to pine trees, unless the pressure-removing tank (pressure relieving step) is used. Breakage of cellular walls and penetration into blocked wall hole pairs cannot be effected unless the high pressure is applied. Thus, injection with sufficiently large amounts of liquid essentially requires high pressure. It is extremely difficult from a theoretical point of view to inject sufficiently large amounts of liquid without being accompanied by deformation or breakdown of the timber, without employing the step of recovery of the atmospheric pressure by the use of the pressure-removing mean as that adopted in the invention of this application.

**[0020]** Accordingly, it is possible to destroy the toruses in the wood material to those at the central portion thereof, so that the present method can be used to inject the treating liquid to the central portion of the

material.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0021]

- Fig. 1 illustrates graphs showing the reduction and application of pressure when the treating liquid injecting method of the present invention is applied to conifers;
- Fig. 2 illustrates graphs showing the reduction and application of pressure when the treating liquid injecting method of the present invention is applied to broadleaf trees;
- Fig. 3 illustrates the internal structure of the conifer;
- Fig. 4 illustrates the internal structure of the conifer;
- Fig. 5 is a cross section illustrating the condition of the wood material after it has been treated with the treating liquid injecting method of the present invention, and that after it has been treated with a conventional treating liquid injecting method;
- Fig. 6 is a block diagram illustrating the arrangement of the treating apparatus for implementing the method of the present invention;
- Fig. 7 is an enlarged sectional perspective view illustrating the structure of the wood material; and
- Fig. 8 is a cross section of the wall pits between the wood material structure.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0022]** The embodiments of the apparatus for injecting a treating liquid into wood material of the present invention will be described with reference to the drawings.

**[0023]** Fig. 1 shows graphs showing the reduction and application of pressure in the first embodiment of the present invention when the method is used to inject the treating liquid into the conifer. Figs. 3 and 4 each illustrate the structure of the conifers. Fig. 5 compares the conditions of the wood material after it has been treated using the treating liquid injecting method of the present invention, and after it has been treated using a conventional treating liquid injecting method. Fig. 6 is a block diagram showing the arrangement of the apparatus used for implementing the present method.

**[0024]** The conifers generally have the structures shown in Figs. 3 and 4. For this reason, it is necessary

to destroy the ray parenchyma cell walls and aspirated pit-pairs to inject the treating liquid to the central portion. In the present method, the pressure is gradually applied from a low pressure to the material to be treated, so that the pressure difference between the internal and external portions of the wood material is maintained, which pressure difference is large enough to destroy the torus 3, but not too large to deform the wood material. Each torus 3 is then gradually destroyed to those at the central portion, allowing the injected treating liquid to permeate sufficiently to the internal portion of the wood material.

**[0025]** First, the ray parenchyma cell walls at the outermost portion and the aspirated pit-pairs are destroyed, and then the pressure in the tracheid 21a is made equal with the external pressure. The pressure in the tracheid 21b, 21c, and the like is made equal with the external pressure as each torus is successively destroyed to those in the heartwood. In this case, the pressure is transmitted through very narrow gaps or small holes. Accordingly, it is necessary to increase the pressure for higher efficiency, but a sudden increase in pressure causes the material to become thinner and become deformed. Consequently, in the present invention the pressure is increased successively in steps so as not to thin and deform the material.

**[0026]** In the pressure-reducing step of the present invention, a treating material 11 is stored and sealed in a pressure vessel 12 comprising the apparatus illustrated in Fig. 6. Then as shown in Fig. 1, the pressure of the material is temporarily reduced to 760 mmHg by a pressure-reducing vacuum pump 13, with the material maintained at this pressure for about 20 minutes, in order to remove as much air from the material as possible. The next step is the pressure-applying step. In the initial pressure-applying step, pressure is applied on the material to 196 kPa (2 kg/cm<sup>2</sup>) by a gas pressure-applying compressor 14. In this case, each portion of the material in the pressure vessel 12 is subjected to the same pressure in accordance with Pascal's law. The material is maintained at this pressure for about 20 minutes. A pressure of 196 kPa (2 kg/cm<sup>2</sup>) is large enough to destroy each torus 3 and the like. As a result, although when the material is maintained at this pressure not all of the ray parenchyma cell walls and aspirated pit-pairs are destroyed, a portion of them are destroyed, allowing pressure to be transmitted to the central portion. At this relatively low pressure of 196 kPa (2 kg/cm<sup>2</sup>), the wood material itself is not deformed.

**[0027]** The next step is the preliminary pressure-applying step. As shown in Fig. 1, the pressure is increased stepwise from a pressure of 196 kPa (2 kg/cm<sup>2</sup>) of the initial pressure-applying step until the final stage of pressure application. In the present embodiment, the pressure is increased to 785 kPa (8 kg/cm<sup>2</sup>), 1471 kPa (15 kg/cm<sup>2</sup>) and 2451 kPa (25 kg/cm<sup>2</sup>)

**[0028]** First, the pressure is increased to 785 kPa (8

kg/cm<sup>2</sup>). Since a pressure of 196 kPa (2 kg/cm<sup>2</sup>) has been applied in the initial pressure-applying step, there is a relative pressure difference of 588 kPa (6 kg/cm<sup>2</sup>) between the internal and external portions of the wood material at the time when the pressure is increased to 785 kPa (8 kg/cm<sup>2</sup>). Though depending on the type of wood material, the torus 3 is usually destroyed when a pressure of 196 to 490 kPa (2 to 5 kg/cm<sup>2</sup>) is applied to it. Accordingly, in the first stage of the preliminary pressure-applying step, a greater number of aspirated pit-pairs, mainly those near the outer portion of the wood material, are destroyed. The material is again maintained at 785 kPa (8 kg/cm<sup>2</sup>) for about 10 minutes. For this reason, in the same way as it is described above, the pressure is transmitted through destroyed ray parenchyma cell walls and aspirated pit-pairs, allowing the wood material to be subjected to a pressure of 785 kPa (8 kg/cm<sup>2</sup>) to its inner portion.

**[0029]** In the preliminary pressure-applying step, the pressure is further increased when appropriate while in each pressure-applying stage the material is maintained at a particular pressure for a certain period of time. That is, in the present step pressure is further applied to the wood material to 1471 kPa (15 kg/cm<sup>2</sup>) for 10 minutes and to 2451 kPa (25 kg/cm<sup>2</sup>) for 20 minutes until the final stage of pressure application. The relative pressure difference which occurs between the internal and external portions of the wood material in each stage successively destroys the ray parenchyma cell walls and the aspirated pit-pairs.

**[0030]** As described above, wood materials are usually deformed when a pressure of 1471 kPa (15 kg/cm<sup>2</sup>) is applied thereto. The materials are, however, deformed due to shock arising from a pressure difference which is caused by a sudden application of pressure from no pressure to 1471 kPa (15 kg/cm<sup>2</sup>). Accordingly, if the pressure is applied in steps to the wood material as it is in the present invention, the wood material is not easily deformed even when the final pressure applied thereto exceeds 1471 kPa (15 kg/cm<sup>2</sup>).

**[0031]** In the present invention, in each stage pressure is applied for a predetermined time so that the internal portion of the wood material is subjected to the pressure of a particular pressure-applying stage. Therefore, even if, for example, a pressure of 2451 kPa (25 kg/cm<sup>2</sup>) is applied, the pressure increase during pressure application is merely the relative pressure difference between the internal and external portions of the wood material. That is, the pressure which the wood material experiences is merely 981 kPa (10 kg/cm<sup>2</sup>) [2451 kPa (25 kg/cm<sup>2</sup>) minus the previous applied pressure of 1471 kPa (15 kg/cm<sup>2</sup>)], causing no deformation.

**[0032]** Accordingly, according to the present invention the preliminary pressure-applying steps carried out stepwise allows the aspirated pit-pairs and the like to be destroyed to those at the internal portion of the wood material, without deforming the wood material itself.

**[0033]** In each pressure stage, it is preferable that for the first few pressure application stages of up to about 1471 kPa (15 kg/cm<sup>2</sup>) the material is maintained at a particular pressure for a relatively long period of time of 10 minutes or more, while the length of time can be shortened thereafter.

**[0034]** The pressure and pressure difference for each stage, and the length of time the material is maintained at a certain pressure are naturally set at different values in accordance with the type and dimensions of the wood material. For example, the pressure difference is made large when a large pressure is required to destroy the torus 3, and the material is maintained at a certain pressure for a longer period of time when time is required to equalise the pressure to the inner portion of the wood material.

**[0035]** The preliminary pressure-applying step is followed by the treating liquid injecting step. In the treating liquid injecting step, the treating liquid is injected into the material to be treated with a liquid pressure-applying pump 15 and allowed to spread throughout the material under a certain pressure. In this case, the gas of the material remaining in the tracheid 21 is introduced into the injected treating liquid under applied pressure in accordance with Henry's law.

**[0036]** The material can be treated at the same pressure as the final applied pressure in the preliminary pressure-applying step, or can be treated at a different pressure. In the present method, the preliminary pressure-applying step allows the treating liquid to easily permeate to the internal portion of the wood material because the ray parenchyma cell walls and the aspirated pit-pairs to those in the internal portion have already been destroyed. Therefore, the material can be treated at a pressure lower than the conventional treating liquid injecting pressures.

**[0037]** After injecting the treating liquid under applied pressure, it is necessary to remove the pressure from the pressure-applied material. In this case, a sudden removal of the pressure causes a rapid expansion of the gas introduced into the treating liquid in accordance with Henry's law, so that the material itself may be destroyed. For this reason, in the present embodiment a pressure-removing tank 18 is particularly installed in the treating apparatus, to which tank is previously applied pressure to eliminate pressure differences with that in the pressure vessel 12. From the pressure-removing tank 18, the pressure is gradually removed via the pressure-removing valve 19, allowing the gas dissolved in the treating liquid to escape first. The gas dissolved in the treating liquid, which has a low molecular weight, flows out of the material first, so that the treating liquid accumulates in the internal portion of the material.

**[0038]** The condition of the wood material treated using the treating liquid injecting method of the present embodiment, and that treated using a conventional treating liquid injecting method are shown in Fig. 5 for comparison. A water-soluble dye was injected using the

present method and a conventional method, and then each treated wood material was cut for comparison (Japanese cedar and radiator pine heartwood having a water content of 55% and measuring 20 x 20 x 100 cm were used). As is apparent from Fig. 5, the wood material treated by a conventional method only permits a small amount of treating liquid to enter from the cut end face, and almost no treating liquid is injected from the other faces. On the other hand, according to the present method the treating liquid is injected from any direction, from the cross-grain, straight-grain, and the like. That is, according to the present method the ray parenchyma cell walls and the aspirated pit-pairs in the material are destroyed for injecting the treating liquid, so that the treating liquid is consistently injected not only into the material's surface but to its central portion, thereby posing no problems when heartwood is used as the material to be treated. The present embodiment comprises the steps of a preliminary pressure-applying step using gas followed by the injection of the treating liquid, in which the aspirated pit-pairs and the like are first destroyed, but it may comprise a step in which the treating liquid is injected directly in steps under applied pressure. In this case, the treating liquid is injected by storing the treating material 11 in the pressure vessel 12 and filling up the vessel with the treating liquid, and then applying pressure. The injection amount is adjusted by the pressure, and checked with a liquid-pressure level gage 17 installed in a liquid tank 16.

**[0039]** Usable liquids to be injected include vegetable oil and mineral oil emulsified and made water-soluble by cationic surfactants to which are mixed antiseptics, insecticides, ant killer substances, and mould retarders. The treating liquids to be injected, which are cationic, combine ionically with the anionic wood material to prevent leakage from the wood material, making them suitable treating liquids. Compared to water-soluble glycols used as treating liquids, these treating liquids prevent leakages from occurring and have better dimensional stability and the like over a longer period of time. In addition, emulsifying them by non-ionic and anionic surfactants and adding antiseptics thereto allow the same effects to be obtained. Further, since in the present method the treating liquid can be injected to the central portion of the wood material, a treated material having a higher flame resistance than the conventional treated materials can be obtained by the injection of flame retarders.

**[0040]** A second embodiment of the treating-liquid injecting method related to the present invention will be hereunder described. The second embodiment is a method for injecting the treating liquid into broadleaf trees. Fig. 2 illustrates graphs showing the reduction and application of pressure during the treatment.

**[0041]** Unlike the aforementioned conifers, broadleaf trees usually have vessels which pass water. Therefore, it may seem that these vessels can be used to easily inject the treating liquid. However, these ves-

sels actually contain a large amount of impurities such as tylose. Accordingly, applying pressure all at once causes the impurities to get clogged in the vessels, preventing injection of the treating liquid. For this reason, the present embodiment is intended to transmit equal pressure to the central portion of the material and to inject the treating liquid thereto by applying a relatively low pressure which does not cause the impurities to get clogged in the vessels over a long period of time.

**[0042]** The present method sets the pressure-reducing time at 60 minutes which is longer than that set for the conifers as shown in Fig. 2, in view of the fact that the broadleaf trees contain more elements in their vessels compared to the conifers, which makes it necessary to minimise the extent of vessel clogging occurring during pressure application by removing as much gas in the vessel as possible.

**[0043]** Even in the following pressure-applying step, a relatively low pressure of about 147 kPa (1.5 kg/cm<sup>2</sup>) is applied, so that the dogging in the vessels does not occur. The pressure-applying time is set at 30 minutes, which is longer than it is for the conifers (refer to Fig. 2). Accordingly, the vessels can be set at a certain pressure, without being hampered by vessel clogging. After a low pressure is applied for a long period of time, the pressure is applied in steps at 686 kPa (7 kg/cm<sup>2</sup>) for 10 minutes, 2942 kPa (30 kg/cm<sup>2</sup>) for 30 minutes, and so on.

**[0044]** In this case, the pressure on the broadleaf trees can be increased in a fewer number of steps than for the conifers, since they have a larger number of vessel elements. After the treating liquid has been injected, the pressure is gradually removed using the pressure-removing valve 19 as described above.

**[0045]** The same results as those of the conifers were obtained (Japanese oak and beech heartwood having a water content of 60% and measuring 20 x 20 x 100 were used.)

**[0046]** The pressure may also be applied by using a liquid pump and directly applying pressure by the treating liquid, in addition to using a compressor to apply preliminary pressure with gas and then injecting the treating liquid under pressure. On the other hand, after injecting the treating liquid under high pressure, the pressure-removing valve 19 is used to gradually remove the pressure as described above.

## Claims

1. An apparatus for injecting a treating liquid into wood material comprising:

a pressure vessel (12) for storing and sealing said material (11) to be treated therein;  
a pressure reducing pump (13) for reducing the pressure of said pressure vessel (12) after storing and sealing said material (11) in said pressure vessel (12);

a liquid pressure applying device (15) for introducing the treating liquid from a tank (16) for said treating liquid into said pressure vessel (12) to fill up the vessel (12) with the liquid and apply pressure to inject the liquid into said material (11); 5

a pressure removing tank (18) connected to said pressure vessel (12), whose pressure is previously equalized by gas from a gas pressure applying compressor (14) with the pressure of the pressure vessel (12); and 10

a pressure removing valve (19) which opens to gradually reduce the pressure of said pressure vessel (12) through said pressure removing tank (18); 15

wherein

a) the material (11) is stored and sealed in the pressure vessel (12);

b) the pressure of the pressure vessel (12) is reduced by the pressure reducing pump (13), 20

c) the treating liquid is introduced from the tank (16) to the pressure vessel (12) to fill up the vessel (12) with the liquid and apply pressure to inject the liquid into the material in the pressure vessel (12); 25

d) the gas is applied from the gas applying compressor (14) to the pressure removing tank (18) to previously equalize the pressure of the tank (18) with that of the pressure vessel (12); and 30

e) the pressure removing valve (19) is opened to gradually reduce the pressure of the pressure vessel (12) through the pressure removing tank (18) to obtain a liquid injected material product. 35

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Fig. 1

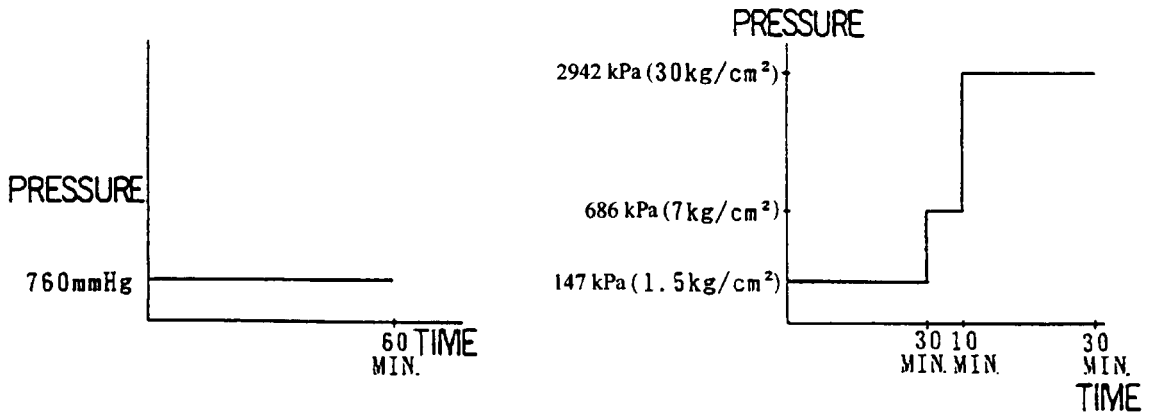
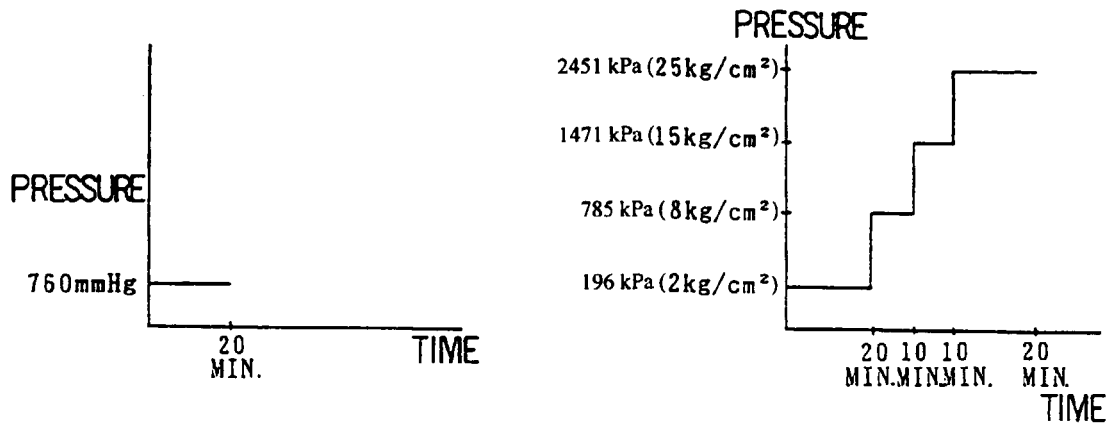


Fig. 2

Fig. 3

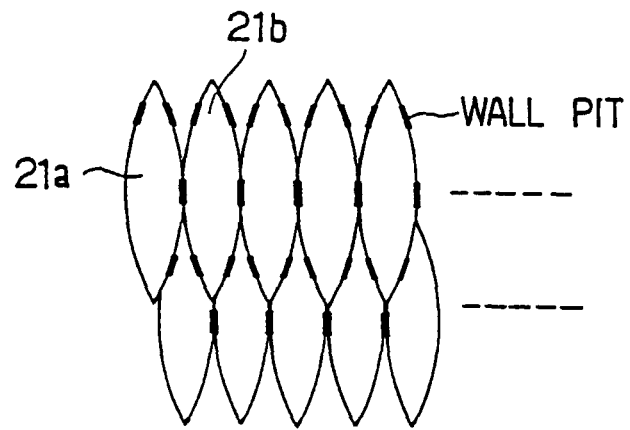
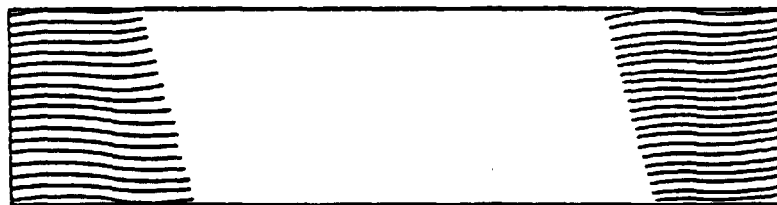
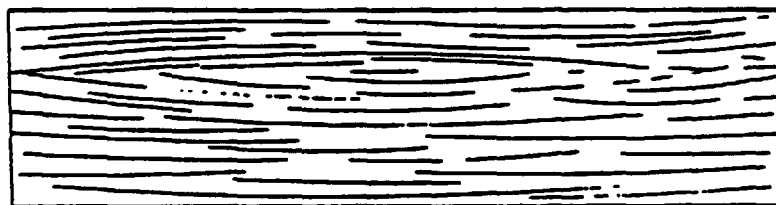


Fig. 4

(a)



(b)



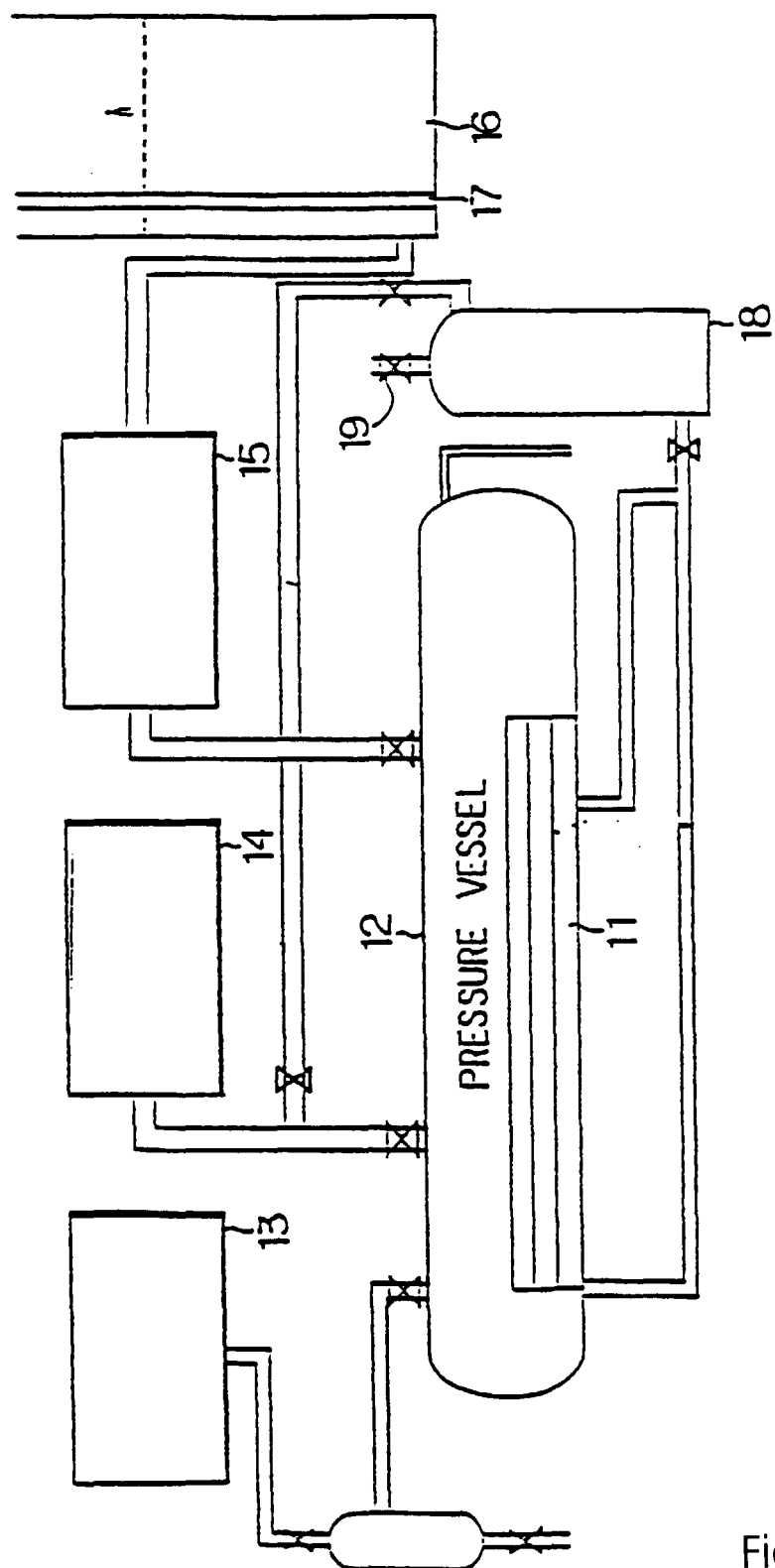


Fig. 5

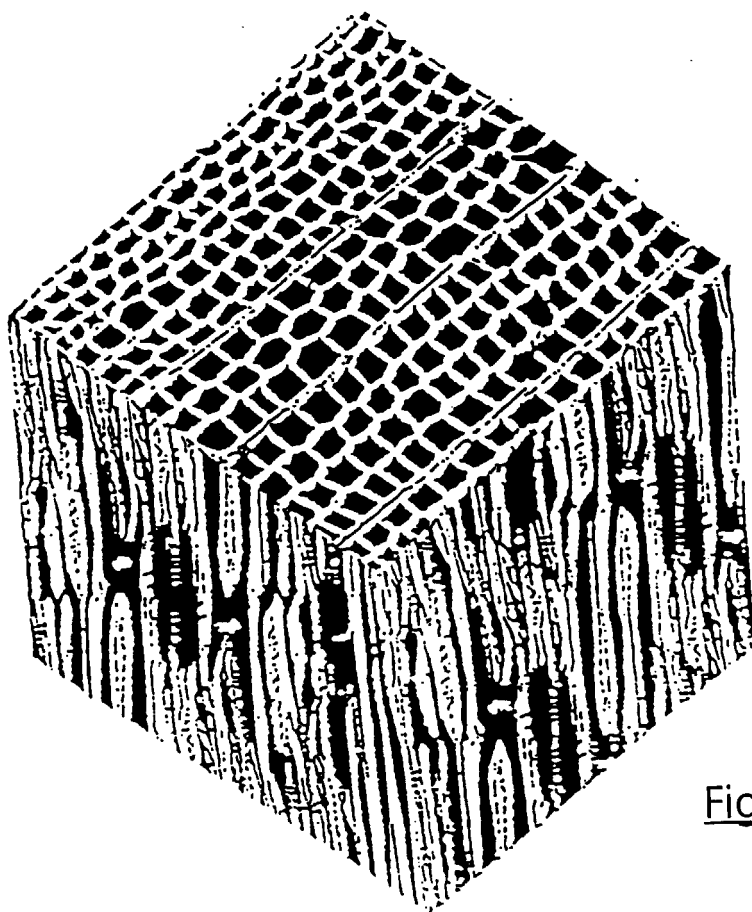


Fig. 6

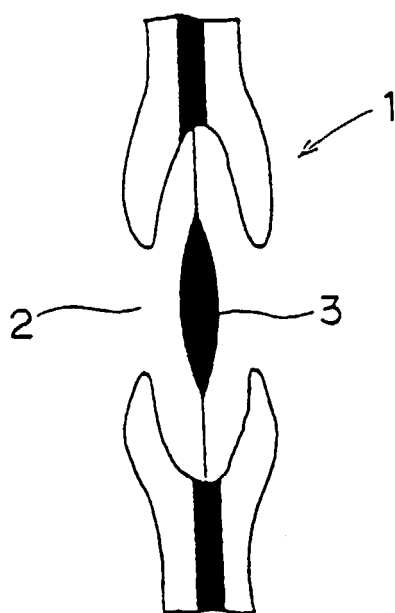


Fig. 7



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 00 10 9861

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                               |                                                    |                                              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------|----------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim                                  | CLASSIFICATION OF THE APPLICATION (Int.Cl.7) |
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| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone<br/>Y : particularly relevant if combined with another document of the same category<br/>A : technological background<br/>O : non-written disclosure<br/>P : intermediate document</p> <p>T : theory or principle underlying the invention<br/>E : earlier patent document, but published on, or after the filing date<br/>D : document cited in the application<br/>L : document cited for other reasons<br/>.....<br/>&amp; : member of the same patent family, corresponding document</p> |                                                                               |                                                    |                                              |

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